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(54) Proteinaceous foaming composition, a method for the production of a foamed proteinaceous product and a method for preparing a continuous surface coating on a substrate.

(57) The combination of certain polyvalent metal ions with certain proteinaceous foaming agents significantly enhances the efficacy of proteinaceous foaming compositions. The present invention affords the means for achieving significantly improved protein foam from vegetable protein hydrolyzates which normally fail to possess the foaming efficacy of conventional proteinaceous foam agents such as egg albumen and caseinates. The improved foamed products may be obtained by employing a combination of polyvalent ions such as calcium and zinc with enzymatically hydrolyzed soy protein whipping agents which are soluble throughout the pH range 4 to 7. The proteinaceous foaming compositions may be utilized for a variety of industrial and food applications and are particularly useful in providing coated paper products.

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Proteinaceous Foaming Composition, a Method for the Production
of a Foamed Proteinaceous Product and a Method for Preparing
a Continuous Surface Coating on a Substrate

This invention relates to a proteinaceous foaming composition, a method for the production of a foamed proteinaceous product and a method for preparing a continuous surface coating on a substrate.

10 A wide variety of industrial, pharmaceutical, animal and food products rely upon foamed or aerated structures. The capacity of such foams to ingest and retain
15 gasses largely depends upon the functional attributes of its hydrophilic film-forming component. Certain naturally occurring hydrophilic film-formers, such as casein and egg
20 albumin, are inherently excellent foam producers and do not require additional or supplemental foaming components. The essential foaming components are apparently indigenously present in such proteinaceous foaming compositions. In
25 contrast, most other hydrophilic film-formers, especially the synthetic foaming compositions, typically require supplemental foaming additives (e.g. foam stabilizers, emulsifiers, thickeners, etc.) to achieve satisfactory foaming properties. These supplemental additives normally
30 create more serious foaming problems than they correct. These foaming problems limit such synthetic foaming compositions to specific applications. The versatility and overall foaming efficacy of the naturally occurring protein foaming agents (e.g. egg albumin or casein) are generally
35 recognized as superior to those foaming compositions formulated with synthetic film-formers, including extensively modified (chemical, physical, enzymatic, etc.) animal or plant proteins.

United States Patent No. 3,814,816 by Robert C.
35 Gunther discloses a pepsin-modified soy protein hydrolyzate foaming agent. These soy protein hydrolyzates are typically made by initially chemically hydrolyzing soy protein followed

by digestion with pepsin. Commercially available pepsin modified soy protein whipping agents disclosed in this patent typically are water-soluble throughout the pH 4.0 - 7.0 range (20% dry protein solids concentration) and remain stable against heat denaturation at temperatures between 25°C - 180°C. Compared to the numerous other synthetic whipping agents, these pepsin-modified soy hydrolyzates possess exceptional whipping properties. In U.S. Patent No. 4,120,987 by Moore, conventional phosphate stabilizers (e.g. ammonium, alkali metal or alkaline earth metal salts of phosphates and polyphosphates) are disclosed as possible confectionery recipe additives.

Within recent years, the paper industry has utilized foams to coat or size paper products. A recently issued patent by Jenkins (U.S. Patent No. 4,184,914) discloses hydrolyzed protein foaming agents capable of reducing surface tension of water from a normal value of 72 dynes per centimeter to minimum value in the range of from 45 to 65 dynes per centimeter as a functional additive for paper coating applications. Illustrative hydrolyzates disclosed by Jenkins include "keratin or albumen such as hoof and horn meal, feathers and blood." Conventional whiteners, or water-insoluble pigments, such as calcium carbonate reportedly may also be formulated into such foaming compositions. Conventional fire fighting foaming compositions which contain the hydrolyzed proteins are also reportedly applicable to this paper coating technology.

British Patent Specification No. 1,368,463 discloses that magnesium chloride, calcium chloride and ethylene glycol are conventionally added to fire fighting foams as anti-freeze additives. Such anti-freeze additives are disclosed as causing precipitation of the surfactants. The surfactants are reportedly essential for foaming. Formamide is proposed as an anti-freezing agent replacement since it will not affect the surfactant functionality in the foaming system. The benefits of using Pyrene Plus F (a fire foam composition) formulated with formamide as an anti-freezing agent instead

of magnesium chloride are reported in Example 1. Chemical Abstracts, Vol. 84 also reports that foaming agents, water-, heat- and chemical-resistant and stable foams for cement products and fire extinguishing applications may be obtained by combining the alkali hydrolyzate products of microbes with certain metallic salts.

The ability of certain proteins to form metal complexes (chelation) is known. A general review of this chemistry is disclosed in The Handbook of Food Additives (2nd Ed) by Furia (CRC Press (1972)). According to Furia: "For chelation to occur two chemical conditions must be satisfied: (1) the ligand must have the proper steric and electronic configuration in relation to the metal being complexed and (2) the surrounding milieu (pH, ionic strength solubility, etc.) must likewise be conducive to complex formation." Illustrative metal/chelating agent complexes disclosed by Furia include: barium, calcium, cobalt, copper, ferrous, ferric, magnesium, manganese, nickel, strontium and zinc ions.

Foams are complex. Certain additives conducive to satisfactory foams in certain systems will often adversely affect other systems. Within the field of proteinaceous materials, it is possible to derive an unlimited number of different film-forming compositions by physically, chemically or enzymatically altering or modifying the protein molecule. Such divergencies apparently arise because of the infinite compositional, molecular, steric and electronic configuration differences therebetween. As a general rule, most proteinaceous film-forming materials (modified or unmodified) are ineffective foaming agents. Even amongst the recognised protein foaming agents, such as egg albumin and casein, different foaming attributes and compatibility with other recipe additives exists. Certain foaming applications will require the unique foaming functionality and compatibility of egg albumin while others will require casein. Additives complementary to egg albumin foam often destroy the unique

foaming efficacy of casein.

A low-cost, whipping protein has long been sought by the art. The vegetable proteins are recognized as a low cost protein source, but generally possess inadequate whipping properties to compete with egg albumin and casein systems. In attempts to improve upon the whipping efficacy of vegetable proteins, a host of chemical, enzymatic and physical processing modifications have been suggested.

An object of the present invention is to improve upon the foaming efficacy of proteinaceous materials and particularly those which are obtained from abundant and low cost raw materials. It has now been discovered that a combination of certain metal ions and protein hydrolyzates will unexpectedly yield superior foams. Laboratory evidence indicates certain water-soluble proteinaceous materials apparently possess at least two different chelating sites which require at least two different types of chelating metal ions to obtain an improved foaming effect. Within the field of soy protein, only certain types of hydrolyzates appear to possess this multi-site functionality. As a result of this discovery, it is now possible to achieve the unique foaming attributes of egg albumin and/or casein from a vegetable protein source. The foaming compositions of this invention may be used in a wide variety of industrial, pharmaceutical and food applications.

The present invention provides a proteinaceous foaming composition containing a proteinaceous foaming component characterised in that it contains at least two different water-soluble polyvalent ions which cooperatively produce a foamed volume greater than the volume obtained on the exclusion of at least one of the metal ions and further characterised in that the proteinaceous foaming component is water-soluble at a pH above or below the isoelectric point of the proteinaceous foaming component when mixed with water at 20°C in a 20% by weight dry solids concentration.

The present invention also provides a method for forming a foamed proteinaceous product which comprises

ingesting an aqueous medium containing a proteinaceous foaming component with a sufficient amount of a gas to provide a foamed product, characterised in that the proteinaceous foaming component is as defined above and the aqueous medium also contains at least two different polyvalent ions as defined above.

The invention further provides a method for preparing a continuous surface coating on a substrate which comprises coating a foamed proteinaceous product produced by the method defined above upon the surface of a substrate and mechanically disintegrating substantially all of the foam to form a continuous surface coating upon the substrate.

An essential component of the present invention is the proteinaceous foaming component. The proteinaceous foaming component in combination with at least two different water-soluble polyvalent metal ions cooperatively produce a foamed volume measurably greater than that volume obtained by the exclusion of at least one of the polyvalent metal ions from the metal ion combination. In general, the proteinaceous foaming component herein will form proteinaceous solutes (i.e. water-soluble) when admixed with 20°C water (20% by weight dry solids concentration level) at a pH above or below the isoelectric point of the proteinaceous foaming component. Illustrative proteinaceous foaming components include the water-soluble animal, plant and microbial proteins and the hydrolyzate products thereof. These water-soluble proteins are generally characterized as film-formers in that when they are applied as an aqueous solution onto a solid substrate (e.g. paper or glass), and then dried by conventional coating techniques, the dried proteins form a protein film or coating.

The proteinaceous foaming components suitable for use according to this invention include those proteins which contain at least two different metal chelating groups and will disperse into aqueous solutions with or without other solutes to facilitate their solubility therein such

as acids, bases, salts, or alcohols. Illustrative proteinaceous foaming components include the simple proteins (e.g. yield only amino acids or their derivatives upon hydrolysis) such as albumins (soluble in water and coagulable by heat); globulins (soluble in salt solutions and heat coagulable); glutelins (soluble in dilute acids or bases); histones (soluble in water or dilute acids, precipitated by ammonia and not coagulated by heat); protamines (soluble in water, uncoagulable by heat); conjugated proteins such as phosphoproteins, chromoproteins, lecithoproteins, etc.; protein hydrolyzates such as metaproteins (e.g. acid or base hydrolyzates); proteoses (soluble in water, not coagulated by heat and precipitated in saturated solution by ammonium or zinc sulfate); peptones (water-soluble, noncoagulable by heat, not precipitated by ammonium sulfate); peptides; and mixtures thereof. Such protein foaming compositions thereof include egg albumin, casein hydrolyzates, keratin hydrolyzates (e.g. from skin, fur, wool, nails, hoofs, horns, scales, beaks, or feathers); vegetable protein hydrolyzates (e.g. soy peptones and soy albumin); whey or milk serum proteins (lactoalbumin); wheat albumins and/or globulins, conalbumin and avidin.

In a more limited embodiment of the invention, the protein foaming component consists essentially of albumins and/or albumin hydrolyzates, and preferably the peptone hydrolyzates. Although such albumin hydrolyzates may be obtained by chemical (e.g. acid or base hydrolysis) or enzymatic hydrolysis (catenase or endocatenase), those albumin hydrolyzates characterised as being water-soluble throughout the pH 4.0 - 7.0 range have been found to be particularly effective protein foaming components. The present invention affords a low-cost and practical means for obtaining effective foams from plant-proteins and particularly from oil-bearing seed materials such as soybean, peanut, peas, bean, sunflower seed, sesame seed and cottonseed.

Although the invention applies to a wide variety of

protein hydrolyzates, effective foams may be obtained from protein hydrolyzates of a low sulfur-containing amino acid content (e.g. cysteine and methionine), particularly the plant protein hydrolyzates of less than 1% sulfur-containing amino acids and preferably less than 0.5% by weight. Vegetable protein hydrolyzates such as those derived from leguminous sources (e.g. peanuts, cottonseed and soybean) are particularly useful for this purpose. Excessive hydrolysis which destroys the film-forming and gas ingestion properties of the protein should be avoided. Soy protein hydrolyzates such as disclosed in U.S. Patent No. 3,814,816 in conjunction with the metal ion combination herein produce superior foamed volumes. These proteins are commercially available and may be prepared by chemical hydrolysis to a prescribed viscosity range and thereafter enzymatically hydrolyzing the soy protein hydrolyzate with pepsin. Such a dual hydrolysis process apparently imparts multi-metal functionality to the soy protein molecules. Alternatively the protein hydrolyzate may be derived from certain water-soluble fractions which are isolated and partitioned from the higher-molecular weight, isoelectric precipitated heat-denaturable proteins. Vegetable protein hydrolyzates which are characterised as possessing film-forming properties sufficient to permit gas ingestion into recipe formulations, remaining water-soluble throughout the pH 4.0 - 7.0 range at a 20% concentration and not subject to heat-denaturization throughout the 25°C - 150°C range, are especially suitable for use as the whipping protein component.

As illustrated by the examples, certain proteinaceous foaming components will cooperatively produce and enhance foamed volume while other closely related proteinaceous foaming agents are unaffected by the presence of the metal ion combination. Substances which chemically, sterically or physically interfere with the protein/metal ion combination interaction should be eliminated from the foaming component as well as the foaming composition. The water-

soluble monovalent proteinates (e.g. sodium caseinate and sodium soy proteinates) effectively inhibit or destroy the foaming efficacy of the protein molecules and the polyvalent metal ion combination. Likewise, indigenous and extraneous contaminants such as carbohydrate (e.g. glycoproteins), which interfere with the metal ion/protein foaming component combination, should be eliminated from the system. Accordingly, it is advantageous to use a proteinaceous material having a protein content of at least 50% by weight and preferably at least 70% by weight protein (e.g. soy protein concentrate) as the proteinaceous foaming component. Tests also tend to indicate that soy hydrolyzate products produced by endoproteases, such as pepsin, result in more efficacious protein foaming components than those obtained from only chemical catenase or exoprotease hydrolysis.

The foaming composition of this invention rely upon a combination of at least two metals which collectively produce a greater foamed volume in comparison to that obtained by the separate use of each metal ion. On an equal molar concentration basis, the metal ion combination, as opposed to the separate use of only one of the metal ions, will generally decrease the foamed density by at least 10% and most typically by at least 15%. The metal ion combination permits a more uniform inert gas ingestion and retention throughout the foamed structure. This apparently arises because of the exceptional elasticity and strength which the metal ion combination imparts to the protein foaming agent. This improvement permits a more homogeneous distribution of the ingested gas, as minute gas bubbles, throughout the foamed structure. Consequently a lesser amount of protein may be used to achieve an equivalent volume of foam in a wide variety of foaming applications. The improved foaming efficacy and low protein foaming agent costs represents a substantial raw material cost savings to the foam manufacturer. Other beneficial results occurring to the foam manufacturer include ease of preparation, excellent handling, machinability, coating (e.g. uniformity, adhesiveness,

flow, compatibility and drying) attributes.

5 The particular metal ions necessarily added to measurably increase the foamed volume will depend upon the multi-metal ion coordinating sites of the protein-
aceous foaming component. Illustrative polyvalent
chelating metal ions include Ba⁺⁺, Ca⁺⁺, CO⁺⁺, Cu⁺⁺,
Fe⁺⁺, Fe⁺⁺⁺, Cr⁺⁺, Ti⁺⁺, Zr⁺⁺, Mg⁺⁺, Mn⁺⁺, Cd⁺⁺, Ni⁺⁺,
Sr⁺⁺ and Zn⁺⁺ ions. Polyvalent metal ions containing two
10 electrons in their outer orbital level are best suited
(e.g. 37th Ed. Handbook of Chemistry & Physics, page 255).
The metal ions may be suitably incorporated into the
aqueous foaming composition as water-soluble salts.
Exemplary salts include the polyvalent metal acid salts
such as the acetate, bromate, chloride, chlorate, iodide,
15 nitrate, sulfate, sulfite, lactate, nitrite, thiosulfate
and mixtures thereof. The water-soluble salts of
strong mineral acids (e.g. hydrohalides and sulfuric acids)
are preferred.

20 The metal ion combination of zinc and calcium ions
are particularly effective. Zinc and calcium are similar
to one another in that they both contain two outer electrons
in the 4s level with the internal 1s, 2s, 2p, 3s, 3p levels
being completely filled. Zinc, however, has its full
complement of 3d electrons whereas calcium does not.
25 However, both of these metal ions have a stable and symmetrical
electronic configuration with respect to their inner orbitals.
This may contribute to their unique and superior foaming
attributes herein. This combination is particularly effective
when used in combination with simple proteins and the hydro-
30 lyzate products thereof. Superior foaming efficacy has been
achieved via the use of these metal ions in combination
with water-soluble proteinaceous materials such as egg
albumin, alkali-hydrolyzed casein, keratin hydrolyzates and
chemically and pepsin modified soy proteins. The separate
35 use of either zinc or calcium ions will not yield this
superior foaming effect. By using edible calcium and zinc
water-soluble salts, as the polyvalent metal ion source,

edible foaming compositions may be obtained.

The concentration of the polyvalent metal ions combination added to the foaming composition should measurably increase the total foamed volume comparative to that achieved via their separate use. For most applications, the added metal ion concentration will be greater than 0.002 mole for each nitrogen mole of the foaming composition component. Illustrative foaming compositions relying upon the zinc and calcium ion combination broadly include a total minimum metal ion concentration of 0.005 mole/mole nitrogen (e.g. 0.005 to 0.5 mole/mole nitrogen). Excessive metal ions will not generally affect the foaming efficacy of the system but can adversely affect its functionality in those systems wherein it is desired to reduce the water-solubility of the finished product (e.g. coating applications). For most applications involving calcium and zinc ion combination, the ionic concentration (based on one mole of nitrogen) will typically range from 0.002 mole to 0.1 for the zinc ions (preferably from 0.005 mole to 0.05 mole) and from 0.005 mole to 0.5 mole for calcium ions with the preferred level ranging from 0.01 mole to 0.05 mole.

The foamed compositions of this invention are suitably prepared by initially dispersing the proteinaceous foaming component and the metal ion combination into an aqueous dispersion of an appropriate viscosity for whipping. The overall combination provides a protein system which forms elastic films at the air/water interface with the metal ions facilitating the gas retention of the external film-forming phase. The ease of incorporating gas into the system and the ability to form minute and uniform gas bubbles throughout the aerated structure are evidenced by significantly reduced densities of the foamed product. The water-retention characteristics of the external film phase is improved by steric, chemical and polar alignment of the molecules within the whipping composition. The water-attractive forces of the metal ions, the polar

alignment of the protein molecules and the water adsorption properties of the film contribute to the homogeneity and amount of water which may be bound by the foamed composition.

Depending upon the desired end-use, other additives such as flavoring, coloring agents, microcides, anti-oxidants, humectants, fats, oils, surface active agents and particulates may be formulated with the foaming composition, provided they do not destroy its foaming characteristics. A variety of natural or synthetic hydrophilic film-formers or gums may be used in minor amounts, as thickening or viscosity-modifying agents. Illustrative thereof are water-soluble or water-dispersible celluloses (e.g. methyl, carboxymethyl, hydroxypropyl and hydroxyethyl celluloses), seaweed extracts (e.g. agar, carrageenan and furcellaran), tree extrudates and extracts (e.g. ghatti, arabic, larch, karaya, arabinogalactan and tragacanth), seed or root gums (e.g. guar, locust bean and quince seed), microbial gums (e.g. dextran and xanthans), gelatin pectin, modified and emulsified starch-bearing materials, vinyl polymers (e.g. polyvinylpyrrolidene and polyvinyl alcohol), acrylic polymer, polyacrylic acid, polyacrylamide, polyethylene oxide and mixtures thereof. Such starch-bearing materials include granular, prepasted, hydrolyzed (enzymatically or chemically), derivatized starches, starch fractions and dextrin. A wide variety of starch derivatives (e.g. starch ethers and esters, including cationic, non-ionic, anionic, amphoteric) may be used as ancillary film-forming additives. Typical derivatized starch-bearing materials include oxidized starch, starch phosphates, starch esters (the fumarates, acetates, propionates, succinates, glutamates, citrates, maleates and itaconates), alkyl ethers (e.g. ethyl, propyl and butyl starch ethers) and the hydroxyalkyl starch ethers, carboxyalkyl starch ethers, nitrogen-containing starch ethers (e.g. such as the cationic starches frequently used in paper and textile sizing operations), phosphonium starch ethers, starch carbamates, starch xanthates, sulfuric acid

derivatives of starch and mixtures thereof.

The aerated confections are ingested with a sufficient amount of gas to provide a foamed product. Conventional aerating gases (e.g. air, nitrogen, carbon dioxide, nitrogen oxide, halogenated hydrocarbon such as used as propellant and refrigerant) may be used. The aeration may be conducted batch-wise or continuously in conventional aerating equipment such as Hobart mixers, Savage beaters, Votators and Oakes mixers.

In a more limited embodiment of the present invention there is provided a dry foaming composition which is adapted upon reconstitution with water and aeration to provide a foamed product, said dry foaming composition consisting essentially of proteinaceous film-forming component and a combination of at least two metal ions of differing atomic numbers, with said metal ions being present in said dry foaming composition in an amount sufficient to reduce the density of the foamed product prepared therefrom when said dry composition is reconstituted in water and aerated with an inert gas. These dry foaming compositions are ideally suited for use in a wide variety of foaming applications. The dry foaming compositions may be suitably prepared by dissolving the proteinaceous foaming component and water-soluble salts of the metal ion combination into aqueous solutions and drying the resultant solution to provide a dry foaming composition thereof. Conventional drying techniques such as vacuum-, freeze-, drum- and spray-drying techniques, may be used to dry the foaming composition completely. If the proteinaceous foaming component is susceptible to heat-denaturization (e.g. egg albumin), denaturization thereof should be avoided by maintaining the aqueous solution and drying conditions below the heat denaturization temperature of the protein component.

Water-soluble vegetable protein hydrolyzates not susceptible to thermal denaturization (e.g. at 25°C to 150°C) afford definitive advantages over the heat-denaturable

proteins in these dry foaming compositions. Bacterial and enzymatic contamination may be effectively alleviated by appropriately sterilizing or pasturizing the foaming composition ingredients during the preparation of the dry foaming composition. The water-soluble prerequisite properties of the proteinaceous foaming component are unaffected by such thermal processing conditions.

Alternatively, the aqueous solution may be aerated with an inert gas by conventional techniques prior to the drying thereof. This will facilitate drying as well as creating minute entrapped gas sites homogeneously dispersed throughout the dried foaming composition. These minute gas bubble sites effectively increase the surface area and porosity of the dried foaming composition. This permits more rapid and complete dissolution of the foaming composition upon aqueous reconstitution. In addition, the presence of these minute gas sites in the dry foaming composition will provide minute nucleating sites to facilitate gas ingestion in the foam preparation step. This affords a more homogeneous distribution of the ingested gas in the form of minute gas bubbles within the foamed product.

The water-soluble polyvalent metal ions in the dry foaming composition also enhances the rate at which the proteinaceous foaming component will dissolve into aqueous systems. When reconstituted, these water-soluble metal salts (which are uniformly embedded within the proteinaceous foaming matrix agent) rapidly dissolve to increase the liquid/solid interface surface area and therefore permit more rapid dissolution of the protein foaming component into reconstituting aqueous medium.

If desired, other conventional foaming additives such as mentioned above may be incorporated into the aqueous solution prior to the drying thereof. The dry foaming composition may also be combined with all of the other finished recipe additives to provide a dry

foaming composition which may be directly converted to the finished recipe product. Alternatively, the dry foaming composition may be dry blended in a dry free-flowing granular form along with other recipe additives to provide a complete or partial dry mix.

The foamed proteinaceous products of this invention may be prepared by conventional aerating techniques. The foamed products are unusually effective in the manufacture of paper products sized with a proteinaceous material by conventional foam sizing processes such as disclosed in British Patent Specification 1,039,540 and U.S. Patent 4,184,914. In such sizing paper manufacture, the proteinaceous foam is applied to the surface of a substrate (e.g. paper, paper board, etc.) then mechanically disintegrated (e.g. by passing the foam-coated paper through pressure rolls) to form a continuous proteinaceous surface coating and dried to provide a dry film coating upon the surface of the substrate.

The mole of protein nitrogen determinations for the proteinaceous foaming component were made by the A.O.A.C. 2.051 (1970 Ed.) Kjeldahl method.

The invention is illustrated by the following Examples.

EXAMPLE 1

A spray-dried proteinaceous foaming composition containing protein whipping agent concentrate in combination with calcium zinc ions was prepared. A proteinaceous foaming agent utilized in this example was prepared in accordance with Example 1 of U.S. Patent 3,814,816 (Gunther D-100 Whipping Agent manufactured by A.E. Staley Manufacturing Company, Decatur, Illinois, U.S.A. An aqueous solution of the proteinaceous foaming agent was concentrated in a vacuum evaporator at a temperature not exceeding 63°C to a 37 to 38% solids level as determined by a calibrated sugar refractometer. Under vigorous agitation, there was then respectively added zinc chloride and calcium chloride

dihydrate in amounts equal to 1.33% and 2.66% of the final product dry weight. The salts were incorporated into the concentrated protein solution by separately predissolving an equivalent weight amount of zinc dichloride (11.34 kg (25 pounds)) and calcium chloride (22.68 kg (50 pounds)) in water. The resultant metal-containing proteinaceous solution was cooled to 30°C. with continuous agitation. The resultant homogeneous solution was then pumped to a DeLaval vertical spray dryer equipped with a SC-107 spray nozzle and operated at an inlet temperature of 149 to 163°C (300 - 325°F), and an outlet air temperature of 88 - 89°C (190 - 195°F). The proteinaceous metal-containing solution was fed to the spray dryer under a pressure of 253 to 267 kg/CM² gauge (3600 to 3800 psig). The spray dryer was operated so as to yield a product having a 7% maximum moisture content. The resultant spray-dried product was ground and screened through a 40mesh screen. The resultant spray-dried product contained less than 7% by weight moisture, a protein content of approximately 77% by weight, less than 19% ash, a pH of 5 to 5.6, a maximum fat content of 0.4% by weight.

Proteinaceous foams were then prepared from the spray-dried foaming composition by reconstituting 1 part by weight foaming agent into 400 parts by weight water. The foams were prepared by ingesting air into the reconstituted foaming composition in an Oakes Model 4MB2A pressure beater operated at an air supply of .0073 to .0010 cu m per minute (.26 to .37 cubic feet per minute) at 7.03 kg/CM² (100 psi), 1340 r.p.m. rotor speed, 300 ml. per minute feed rate, a 152.25 cm by 0.79 cm (5' by 5/16") outlet tubing configuration and an average outlet temperature of 87°C (124°F). The resultant foam product had an average density of .208 grams/ml. For comparative purposes, the same protein whipping agent without any metal additives was similarly reconstituted and prepared into a foam product. The average foam density for this product was only .298 grams/ml.

EXAMPLE II

Run 1 - Control

Twenty grams of industrial grade modified corn starch (Gunther D-100 W.A., A.E. Staley Manufacturing Company, Decatur, Illinois, U.S.A.) was hydrated in 180.0 ml. distilled water. To this was then added 0.9 grams of spray-dried enzyme modified soy protein whipping agent (STAZYME GNW starch, A.E. Staley Manufacturing Company, Decatur, Illinois, U.S.A.). This mixture was then placed in a 0.805 litre (3-1/1 U.S. qt.) mixing bowl for a Hobart C100 vertical-type mixer and beat at high speed for 30 minutes (using the Hobart's wire whisk agitator). A 0.436 gram/ml. foam density was obtained thereby.

Run 2

To illustrate the efficacy of Zn++ and Ca++ ions, the above Run 1 was duplicated except that 0.025 gram ZnCl₂ and 0.050 gram CaCl₂·2H₂O were added prior to foaming. The density of the foamed product was 0.252 gram/ml. which represents a 42.2% improvement over the Run 1 control.

Run 3

Run 2 was repeated by substituting other commercially available whipping agents for the spray-dried soy albumin whipping agent:

	<u>Density</u>	
	<u>with Ca++ and Zn++</u>	<u>w/o Zn++ and Ca++</u>
A. Spray dried egg albumen (Henningsen Spray dried egg white solids, Type P-20, Henningsen Foods White Plains, N.Y., U.S.A.)	0.370 g/ml.	0.623 g/ml.
B. Alkali hydrolyzed caseinate (Hyfoama DS Lenderink & Co. N.V., Schiedam, Holland)	0.151 g/ml.	0.235 g/ml.

Run 4

H ₂ O	- 88.58%
Starch	- 9.54%
Foaming protein	- <u>1.88%</u>
	100.00%

A cooked starch/whipping agent (Gunther D-100 W.A., A.E. Staley Manufacturing Company, Decatur, Illinois, U.S.A.) mixture consisting (weight basis) of 88.58% water, 9.54% industrial starch (STAZYME GNW Starch, A.E. Staley Manufacturing Company, Decatur, Illinois, U.S.A.) and 1.88% foaming protein (Foaming Protein - Gunther R308 - A.E. Staley Manufacturing Company, Decatur, Illinois, U.S.A.) was fed to Oakes mixer as described in Example I. Machine output was allowed to stabilize before taking multiple (at intervals of ~5 minutes) samples for density determinations. Average values for foam densities were 0.250 gram/ml. at an average outlet temperature of 48.8°C (119.8°F).

Run 5

Run 4 was repeated with the exception that 0.059% ZnCl_2 and 0.10% $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ was included into the formulation prior to whipping. Average density values were 0.169 gram/ml. at an average outlet temperature of 53.8°C (128.9°F).

Run 6

A foamed protein product was prepared by reconstituting 12.1% modified starch (STAZYME GNW) and 1.9% foaming protein (Gunther D-100 W.A.) into water. The cooked starch/whipping protein mixture was fed to the Oakes mixer according to Run 5. Average foam density was 0.327 gram/ml at an average temperature of 54.0°C (129.3°F).

Run 7

Run 6 was repeated employing a cooked starch/foaming protein/salt mixture containing 85.850% water, 12.090% starch, 1.900% foaming protein, .054% ZnCl_2 and 1.106% $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$. Average density obtained thereby was 0.213 gram/ml. at an average outlet temperature of 60.0°C (140.0°F). In Runs 6 and 7, the starch level was increased to place additional stress on the foaming protein.

Run 8

Foams were prepared in accordance with the methodology of Run 7 employing 89.315% water, 9.624% starch (STAZYME GNW)

and 1.060% foaming protein (Gunther D-100 W.A.). The average foamed density was 0.298 gram/ml at an average outlet temperature of 51.1°C (124.0°F).

Run 9

5 Foams were prepared in accordance with the methodology of Run 7 employing 89.231% water, 9.614% starch, 1.131% foaming protein, .009% $ZnCl_2$ and .015% $CaCl_2 \cdot 2H_2O$ to yield an average foam density of 0.201 gram/ml. at an average temperature of 54.1°C (129.4°F)
10 outlet.

EXAMPLE III

This example illustrates the utility of the present invention in preparing foamed edible food products.

15 Run 10

Marshmallow suitable for cutting and coating was prepared from the following:

	<u>Formula</u>	<u>%</u>	<u>grams used</u>
	Gelatin - 225 bloom	2.04	4.1
20	H_2O	18.14	36.3
	Sugar-granulated	36.28	72.6
	Corn syrup - 42 D.E.	43.54	87.1
	Flavor	-	-
		100.00%	200.1 grams

25 Procedure:

1. Using half of the water in the formula, soak gelatin minimum of 15 minutes.
2. Using balance of water, dissolve sugar - will require heating.
- 30 3. Weigh corn syrup into 0.805 litre 3-1/2 U.S. qt.) bowl of C100 Hobart beater.
4. Combine sugar solution, gelatin with syrup, mix well.
5. Using wire whisk, beat in 2nd speed (medium) to
35 density of 0.45 g/ml.

Density of the resultant marshmallow product after whipping 10 minutes was 0.477 gram/ml. This material was slabbed,

cooled and held for comparison.

Run 11

<u>Formula</u>	<u>%</u>	<u>grams used</u>
Gelatin - 225 bloom	2.045	4.1
H ₂ O	18.11	36.3
Sugar-granular	36.22	72.6
Syrup - 42 D.E.	43.46	87.1
Flavor	-	-
ZnCl ₂	.055	0.11
CaCl ₂ ·2H ₂ O	<u>.110</u>	<u>0.22</u>
	100.000%	200.43 grams

The procedure for this run was exactly the same as for Run 10 above. Whipped density after 10 minutes was 0.457 gram/ml. This material also was slabbed, cooled and held for comparison.

Samples of both marshmallows were placed in elevated temperature storage (45-50°C). After ~ 24-hour storage, the Run 11 sample possessed a significantly better texture than the Run 10 sample.

Run 12

Meringue formulation:

<u>Formula Base Mix</u>	<u>%</u>	<u>grams used</u>
Egg albumen (Henningsen Spray dried egg white solids, Type P-20)	15.0	7.5
Foaming protein (Gunther D-100 W.A.)	13.0	6.5
Pregel starch (REDISOL 333, A.E. Staley Mfg. Company, Decatur, Illinois, U.S.A.)	25.0	12.5
Dextrose (STALEYDEX 333, A.E. Staley Mfg. Company, Decatur, Illinois, U.S.A.)	40.0	20.0
NaCl	2.5	1.25
Carrageenan (Viscarin 402, Marine Colloids, Springfield, New Jersey, U.S.A.)	2.0	1.00
Sodium aluminum sulfate	1.7	-
CMC (7HSXP CMC, Hercules, Wilmington, Delaware, U.S.A.)	<u>.8</u>	<u>.4</u>
	100.0%	49.15 grams

Procedure

1. Dry blend all ingredients in 0.805 litre (3-1/2 U.S. qt.) C100 Hobart bowl.
2. Weigh 268 g. sugar, dry blend with other ingredients.
3. Add 300 ml. water at 66 - 77°C (150 - 170°F) to dry mix.
4. Mix 1 minute in slow speed using wire whisk.
5. Beat in medium speed (2nd) for approximately 8 minutes. Density should be 0.2 - 0.25 gram/ml.
6. Spread on pie and bake at 190°C (375°F) for 12 - 14 minutes.

After 8 minutes whip, meringue density was 0.280 gram/ml with weak peaks formed when tested with spatula.

Run 13

Run 12 was repeated with the exceptions that 0.175 g. ZnCl_2 and 0.35 g. $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ were added in addition to other ingredients. The meringue reached peak whipped volume after approximately 4 minutes although test ran for 8. Density after 8 minutes was 0.266 gram/ml. Firm peaks were formed when tested with spatula.

EXAMPLE IVRun 14

Forty grams starch (STAZYME GNW) was hydrated in 360 g. distilled H_2O , placed in 0.805 litre (3-1/2 U.S. qt.) bowl of Hobart C100 mixer. To this was added 0.9 gram soy whipping protein agent (Gunther D-100 W.A.). The combined materials were beat in high speed for 30 minutes using the Hobart's wire whisk. Temperature was maintained at 65.6°C (150°F) for the duration of the test. Final foam density was checked by filling a container of known volume and weight. Calculated density was 0.502 gram/ml.

Run 15

Forty grams starch (STAZYME GNW) was hydrated in 360 grams distilled H_2O placed in 0.805 litre (3-1/2 U.S. qt.) bowl of Hobart C100 mixer. Added 0.86 g. soy protein

whipping agent (Gunther D-100 W.A.), 0.025 g. $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$,
0.012 g. CdSO_4 . The combined materials were beat in high
speed while maintaining the mix temperature at 65.6°C
(150°F). Total whip time again was 30 minutes. Foam
5 density was calculated at 0.442 gram/ml.

Run 16

Forty grams starch (STAZYME GNW) was hydrated in
360 grams distilled H_2O placed in 0.805 litre (3-1/2 U.S.
qt.) bowl of Hobart C100 mixer. Added 0.86 g. soy protein
10 whipping agent (Gunther D-100 W.A.), 0.025 g. $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$,
0.020 g. CdSO_4 . The combined materials were beat in high
speed for 30 minutes while maintaining a mix temperature
of 65.6°C (150°F). Calculated density was 0.380 gram/ml.

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CLAIMS:

1. A proteinaceous foaming composition containing a proteinaceous foaming component characterised in that it contains at least two different water-soluble polyvalent ions which cooperatively produce a foamed volume greater than the volume obtained on the exclusion of at least one of the metal ions and further characterised in that the proteinaceous foaming component is water-soluble at a pH above or below the isoelectric point of the proteinaceous foaming component when mixed with water at 20°C in a 20% by weight dry solids concentration.
2. A proteinaceous foaming composition as claimed in Claim 1, characterised in that the proteinaceous foaming component is a vegetable protein hydrolyzate which is water-soluble throughout the pH range 4 to 7, egg albumen or a casein hydrolyzate.
3. A proteinaceous foaming composition as claimed in Claim 1, characterised in that the proteinaceous foaming component is a vegetable protein hydrolyzate which is water-soluble throughout the pH range 4 to 7 at a 20% by weight dry solids concentration, and is not heat-denaturable throughout the temperature range 25°C to 150°C.
4. A proteinaceous foaming composition as claimed in any of Claims 1 to 3, characterised in that one of the metal ions is an alkaline earth metal and the other metal ion is zinc and cadmium.
5. A proteinaceous foaming composition as claimed in any of Claims 1 to 4, characterised in that the proteinaceous foaming component contains at least 50% by weight protein.
6. A foaming composition as claimed in Claim 1,

characterised in that the water-soluble polyvalent metal ions are zinc and calcium ions, and the protein foaming component is an enzymatically hydrolyzed soy protein having a protein content of at least 70% by weight.

7. A protein foaming composition as claimed in any of Claims 1 to 6, characterised in that the protein foaming composition is a dry foaming protein composition which contains less than 10% by weight moisture and the polyvalent metal ions are calcium and zinc ions.

8. A protein foaming composition as claimed in Claim 7 characterised in that the calcium ion concentration is at least 0.01 mole/nitrogen mole and the zinc ion concentration is at least 0.005 mole/nitrogen mole.

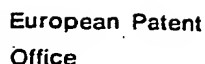
9. A method for preparing a foamed proteinaceous product which comprises ingesting an aqueous medium containing a proteinaceous foaming component with a sufficient amount of a gas to provide a foamed product, characterised in that the proteinaceous foaming component is as defined in any of Claims 1 to 8 and the aqueous medium also contains at least two different polyvalent ions as defined in any of Claims 1 to 8.

10. A method as claimed in Claim 9, characterised in that the aqueous medium containing a proteinaceous foaming composition is prepared by reconstituting a dry foaming composition containing less than 10% moisture, a soy protein hydrolyzate, calcium ions and zinc ions in an aqueous medium prior to the ingestion of gas therein.

11. A method for preparing a continuous surface coating on a substrate which comprises coating a foamed proteinaceous product produced by a method as claimed in Claim 9 or 10 upon the surface of a substrate and mechanically

disintegrating substantially all of the foam to form a continuous surface coating upon the substrate.

12. A method as claimed in Claim 10 wherein the substrate surface comprises paper.



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